Analysis of Flow Resistance in Open Channel for Proper Flow Prediction

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Abstract— *In an open channel flow, the Manning's n depends on the bed material of the channel, the slope of the channel and the rate of discharge in the channel. Experiments are done with two bed materials, the original bed surface of the channel and with grass carper. The roughness coefficient is determined in various cases. The variations in roughness coefficient is tested with respect to flow parameters such as discharge, depth and bed slope. The effect of variations the flow parameters on different bed roughness is also analyzed by taking into account the original flume surface and grass carpet surface.*

Keywords— Channel bed, Manning's "n", Open channel flow, Rectangular flume, Roughness coefficient.

I. INTRODUCTION

Roughness coefficient is very important to determine the flow rate and water level during flood, design of hydraulic structure; open channel drainage system etc. Various types of vegetation and gravel bed give resistance to the flood flows which results turbulence in the flow. Vegetation prevents the erosion on the bank of the channel and controls the movement of soil particles along the channel bottom. Two roughness coefficients are generally used for open channel flow – one is Chezy's coefficient and the other is Manning's coefficient. Out of these two coefficients Manning's n is widely used and it depends on the geometry of the channel, slope of the channel, discharge and roughness of the channel, silting and scouring and obstruction in flow etc. The value of Manning's n extremely varies with the bed and side material. The effect of roughness also affects the state of flow. The Manning's n also depends on the depth of flow, if the depth increases the Manning's n also increases. The bed with varying material it is very difficult to calculate the average e Manning's n. The purpose of this study is to determine the influence of bed material, slope and discharge on roughness coefficient in open channel.

Manning's Equation

$$V = \frac{1}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$$

Where,

V = magnitude of velocity, A = Area, R = A/P where, P= wetted perimeter

S = slope, n = Manning's coefficient

II. LITERATURE REVIEW

In 1891 Robert Manning first introduced the Manning's formula in his paper published in Ireland. Limerinos J. T. (1970) found the Manning Coefficient from measured bed roughness in natural channels. Yen B. C. (2002) pointed out the effects of cross-sectional shape, boundary no uniformity and flow unsteadiness in addition to viscosity and wall roughness that are commonly considered. In 2006 Ismail, Z and Shiono, K. Francisco J.M. Simões,(2010.) derived some equations which was carried out by using only laboratory data with plane beds made of sand and gravel, with both uniform and graded sediments. Omid M. H. (2010) et al conducted an experiment on effects of bed-load movement on flow resistance over bed forms. In 2010, Ji-Sung KIM et.al estimated Manning's roughness coefficient for a gravel-bed river reach using field measurements of water level and discharge, and the applicability of various methods used for estimation of the roughness coefficient was evaluate. Ali1 Md Z. and Saib N. A. (2011) did the laboratory experiment to determine the affects of gravel bed to roughness characteristics in channel.

III. LABORATORY EXPERIMENT

A tilting flume 6m long, 0.30 m wide and 0.46 m deep is taken here for laboratory work as shown fig 1and fig 2. Nine cases are considered; here with three discharges Q1, Q2 and Q3and each discharge each with three slopes 1:100, 1:150 and 1:250 (table 1). Variations of Manning's n with respect to change in Depth of water, Froude's number has been observed and plotted for the above mentioned nine cases from Fig 4 to Fig 12. Another test case number 10 is also studied that is for grass carpet roughness with discharge Q2= 0.00367 m3/sec with bed slope 1:100. The laboratory observations for the tenth case it has been plotted from Fig 13 to Fig 15. Fig-16 shows variation in water depth for different discharge with different slope for the original bed material.

Table 1

No.	Slope	Discharge(**m3/sec**)
Case-1	s=1:100	Q1=0.00384
Case-2	s=1:150	Q1=0.00384
Case-3	s=1:250	Q1=0.00384
Case-4	s=1:100	Q2=0.00367
Case-5	s=1:150	Q2=0.00367
Case-6	s=1:250	Q2=0.00367
Case-7	s=1:100	Q3=0.0012
Case-8	s=1:150	Q3=0.0012
Case-9	s=1:250	Q3=0.0012

Fig 1: Rectangular flume of 6meter length

Fig 2:Flow in the original bed material of the channel

Fig 3:Flow through grass carpet

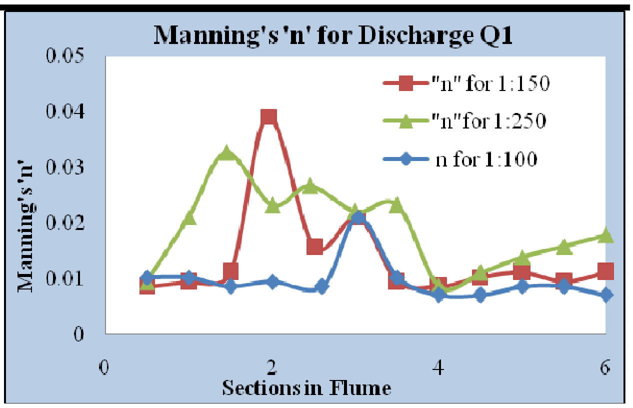

Fig 4: Manning's "n" for Discharge Q1

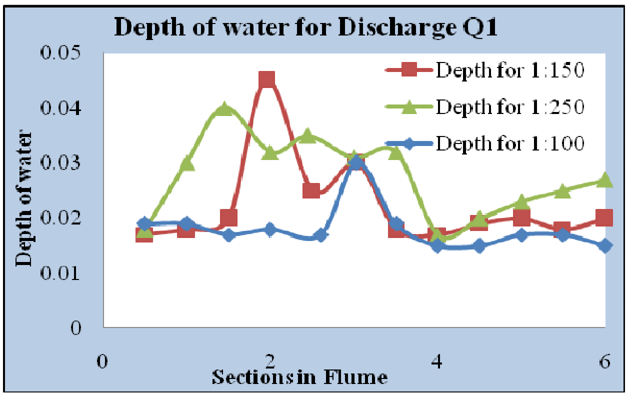

Fig 5:Depth of water for Discharge **Q1**

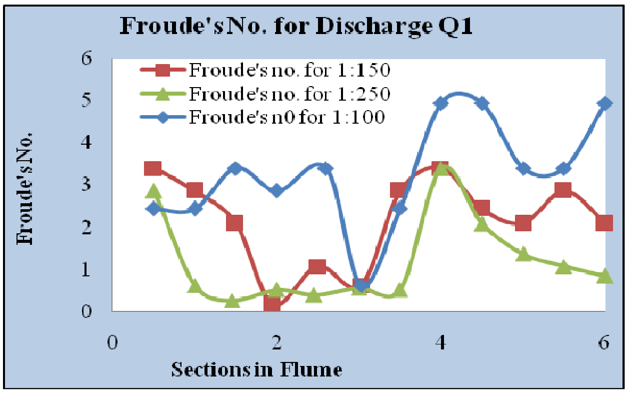

Fig 6:Froude's no. for Discharge Q1

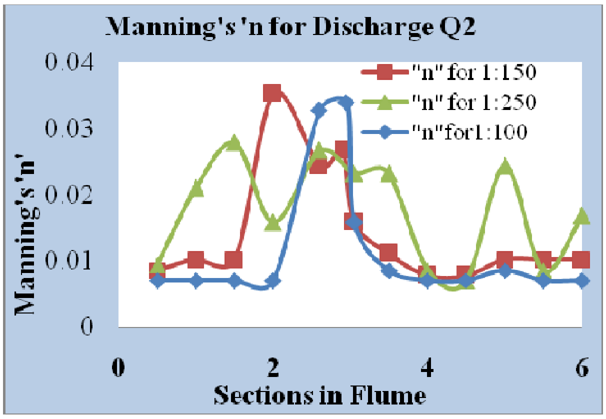

Fig 7:Manning's "n" for Discharge Q2

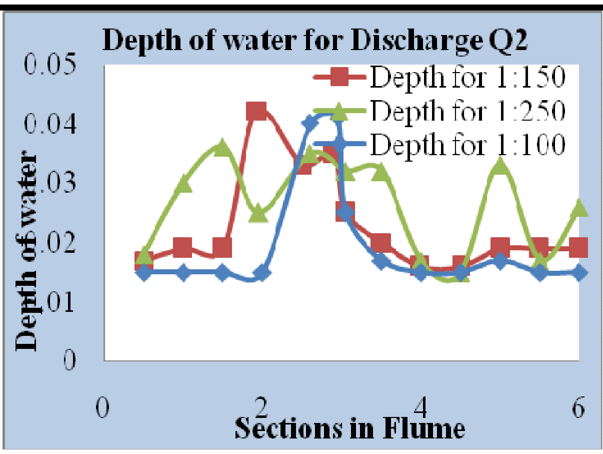

Fig 8:Depth of water for Discharge Q2

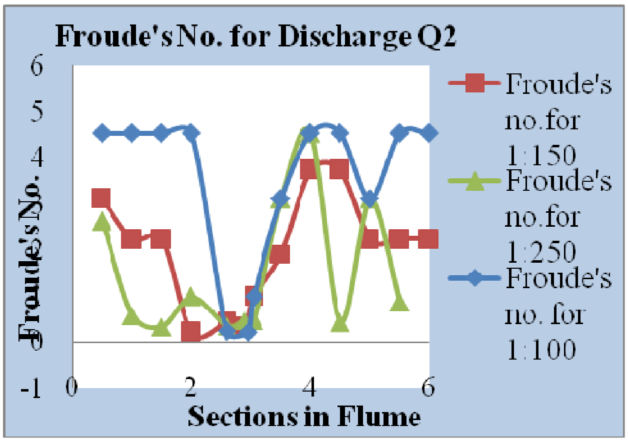

Fig 9:Froude's no. for Discharge Q2

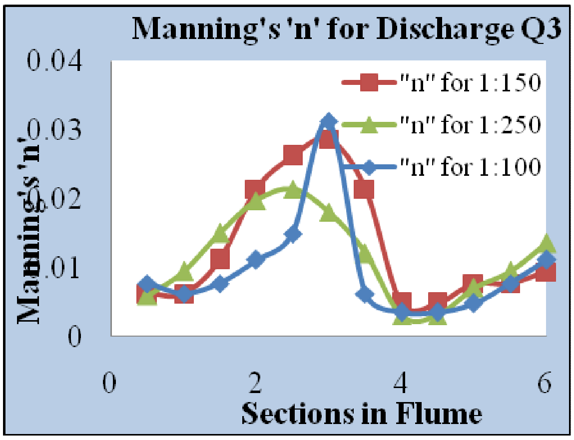

Fig 10:Manning's "n" for Discharge Q3

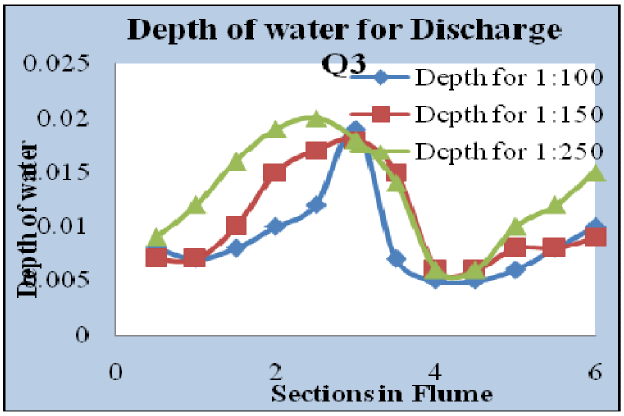

Fig 11: Depth of water for Discharge Q3

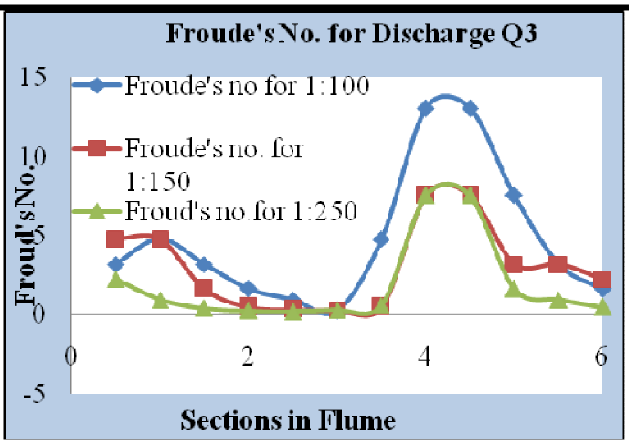

Fig 12:Froude's no. for Discharge Q3

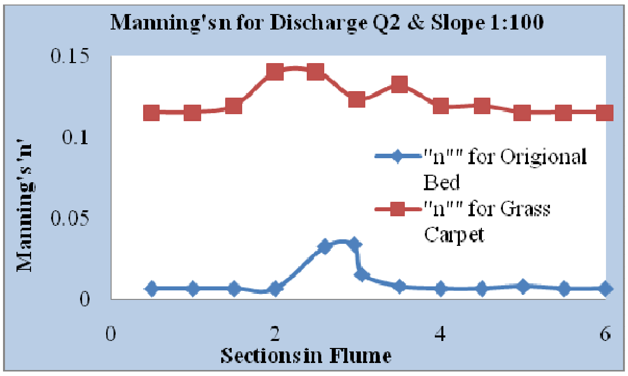

Fig 13: Manning's "n" for Discharge Q2 & slope 1:100

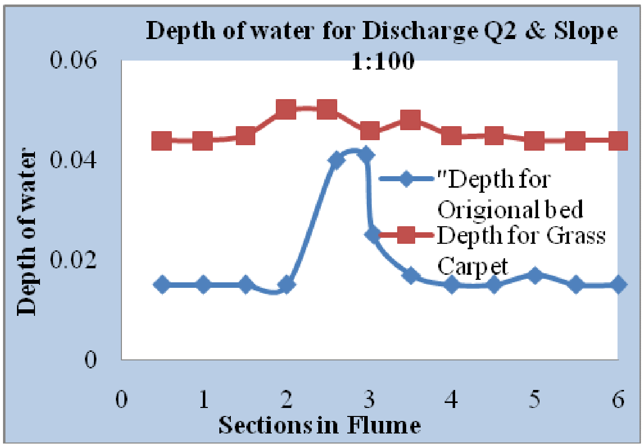

Fig 14:Depth of water for Discharge Q2 & slope 1:100

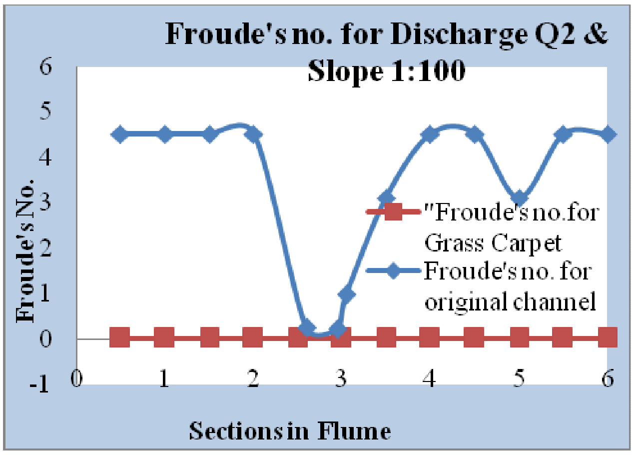

Fig 15:Froude's no. for Discharge Q2 & slope 1:100

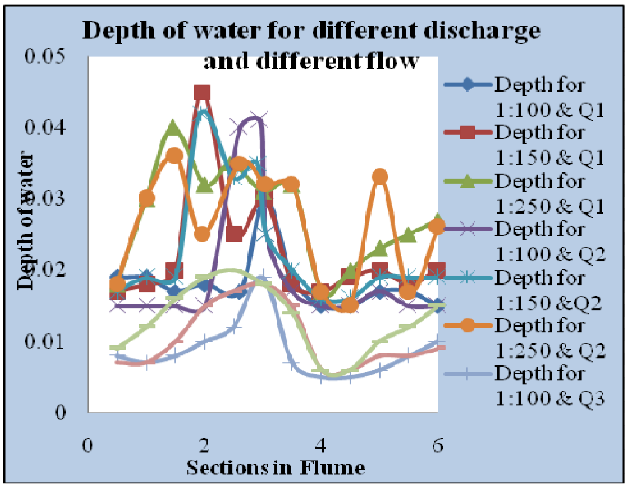

Fig 16: Depth of water for different discharges at different slopes

IV. CONCLUSION

In this experimental study the Manning roughness coefficient "n" is investigated for water flows, within rectangular open channels. The Manning's n is not constant throughout, i.e. it depends on various parameters and not only on roughness factors, especially in channels of combined roughness. "n" appears not to be constant at any present roughness condition and this is due to the nature of flow, where even at the same run its behavior is not constant. The variation in n is more in the original channel bed. "n" increases with the increase in discharge as well as increase in slope. The maximum percentage variation in n is at a distance of 2m to 3.5m from the upstream and it is about 3% to 83% of the average "n" value. The Manning's n for carpet grass is very high and the average value is 0.12. In the carpet grass almost the state of the flow is coming to be uniform i.e. subcritical flow with less variation. In grass carpet the maximum variation is 12% which is at a distance 2m to 2.5m from the upstream. The original bed material of the channel has combined roughness which has a huge effect on the Froude No. also. The variation in Froude's is from 13 to 0.3 i.e. the state of flow changes from highly supercritical flow to subcritical flow. Irregularities of the bed surface of the channel causes an increase in roughness coefficient of the channel. The percentage variation in roughness coefficient in an uniform bed materials is very less as compared to an irregular bed material. The study was mainly concentrated on steady slightly non uniform as a part of our detail study on channel resistance. Further more study is required and accordingly planned for unsteadiness effect on open channel flow resistance. It is also proposed for the extension of the present work for the determination of other open channel resistance like Darcy's "f".

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